MEETING TECHNOLOGY CHALLENGES FOR THE 2007 HEAVY-DUTY HIGHWAY DIESEL RULE

Report of The Clean Diesel Independent Review Panel

(NOTE: This is a DRAFT and NOT yet the conclusions of the Panel)

I. Introduction to the Highway Diesel Rule

Emissions from heavy-duty vehicles contribute significantly to a number of serious air pollution problems. Ground-level ozone, particulate matter (PM), nitrogen oxides (NO_X), sulfur oxides (SO_X), and volatile organic compounds (VOCs) adversely affect public health, contributing to premature mortality, aggravation of respiratory and cardiovascular disease, decreases in lung function and increased respiratory symptoms, changes to lung tissues and structures, altered respiratory defense mechanisms, and chronic bronchitis.[1] In addition diesel exhaust PM, especially from older engines, has been found recently by U.S. EPA as likely to be a cause of increased risk of lung cancer and respiratory disease.[2] [3] Heavy-duty vehicle emissions account for a significant portion of national ambient PM and NO_X levels. Among mobile sources, EPA estimates that by 2007, these emissions will account for 28 percent of NO_X emissions and 20 percent of PM emissions. These proportions are higher in some urban areas. Without stringent controls on heavy-duty vehicles, these serious air pollution problems would increase further.

Recognizing that heavy-duty engines contribute to ozone and PM air quality problems, EPA, California Air Resources Board (CARB), and engine manufacturers have been working for the past decade to substantially reduce emissions from this source. In December 2000, EPA announced Phase 2: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements. This rule was promulgated on Thursday, January 18, 2001, and its emissions requirements will begin to take effect in model year 2007.[1] This second phase of the program is based on the use of high-efficiency catalytic exhaust emission control devices,

particulate filters, and other advanced technologies. The standards also require reducing sulfur in highway diesel fuel by 97 percent (from 500 parts per million (ppm) to 15 ppm) by mid-2006. This ultra-low sulfur diesel (ULSD) coupled with the advanced control technologies on vehicles are projected to decrease particulate matter (PM) and NO_X emissions to levels that are 90 percent and 95 percent below current levels, respectively. Specifically, the PM emissions standard has been set at 0.01 g/bhp-h for model year 2007 for heavy-duty diesel vehicles. NO_X and non-methane hydrocarbon (NMHC) standards are set at 0.2 g/bhp-h and 0.14 g/bhp-h, respectively. These standards will be phased in together between 2007 and 2010, based on a percent-of-sales basis: 50 percent from 2007 to 2009, and 100 percent in 2010.

The program includes a combination of provisions available to refiners to assist in the transition to ultra-low sulfur highway diesel fuel. These include a temporary compliance option, referred to as the 80/20 option, including an averaging, banking, and trading component, beginning in June 2006 and lasting through 2009. Credit is also available for early compliance before June 2006. There are flexibility provisions for refiners subject to the Geographic Phase-in Area (GPA) provisions of the Tier 2 gasoline sulfur program (allowing them to stagger their gasoline and diesel investments), and hardship provisions for small refiners to minimize their economic burden in complying with the 15 ppm sulfur standard.

While environmental and public health organizations as well as some industry stakeholders supported this program, other industry groups challenged specific provisions of the rulemaking in the United States Court of Appeals for the District of Columbia Circuit. After reviewing the arguments of the litigants and the substantial rulemaking record, on May 3, 2002, the District of Columbia Court of Appeals upheld EPA's decisions on the rule.

II. Background to the Clean Diesel Independent Review Panel

As part of the highway diesel rule, EPA agreed to conduct a biennial review of technology progress for reducing NO_X and PM emissions. These technology review reports will be released and posted on the Web, and they will discuss the status of the technology and any

implications for the heavy-duty engine emission control program. The first comprehensive review of the technologies needed to implement the program was conducted and published in June 2002.[4]

On July 30, 2001, EPA Administrator Christine Whitman announced that EPA would request an independent review to provide "advice to the EPA on technology issues associated with the introduction of technology to reduce engine exhaust emissions and technology to lower the sulfur level of highway diesel fuel in accordance with the dates incorporated in the highway diesel program promulgated in 2001."[5] The independent review would be conducted in an open, public process following the requirements of the Federal Advisory Committee Act (FACA). The independent review would operate under the auspices of the FACA as a Subcommittee of the Clean Air Act Advisory Committee (CAAAC).

The Clean Diesel Independent Review Panel (CDIRP) was created by a charter issued under the CAAAC. The purpose of the CAAAC is to provide independent advice and counsel to the EPA on policy and technical issues associated with the implementation of the Clean Air Act (CAA) Amendments of 1990. The CAAAC has approximately 50 members from the regulated and private industry, the academic community, state and local government and environmental organizations. The committee is authorized under the Federal Advisory Committee Act, 5 U.S.C., App. Section 9 (c). It is anticipated that the CAAAC will be consulted on a quarterly basis on economic, environmental, technical, scientific and enforcement issues. The results of these meetings are a written report providing advice to the EPA on implementing the CAA.

The CDIRP was chaired by Mr. Daniel Greenbaum, President of the Health Effects Institute (HEI), Cambridge, MA. Panel members included leading experts from the public health community, environmental organizations, petroleum refiners, fuel distributors and marketers, engine manufacturers, emission control systems manufacturers, State governments, and academia.(see Text Box) EPA representatives served as technical consultants to the panel. The Panel began its work in May, 2002, and Governor Whitman asked the panel to report its findings to her by mid-September, 2002.

Members of the Clean Diesel Independent Review Panel

The purpose of the CDIRP was to review industry's progress in developing the technologies necessary to implement the highway diesel program. The panel was given the following four charge questions:

1. What is the current status of the NO_X adsorber technology to meet the provisions of the HD2007 regulations given diesel fuel with a sulfur cap of 15 ppm? Is industry making progress to develop NO_X adsorbers in a timely manner? Are the necessary resources and plans being put in place to ensure that the technology is available in 2007? What other technologies are being pursued/developed to enable or facilitate the application of NO_X adsorbers?

2. What is the current status of catalyzed diesel particulate filters to meet the provisions of the HD2007 regulations given diesel fuel with a sulfur cap of 15 ppm? Is industry making progress to develop the catalyzed diesel particulate filter in a timely manner? Are the necessary resources and plans being put in place to ensure that the technology is available in 2007?

3. Which refiners have announced their plans for producing low sulfur diesel fuel by June 2006? Where are refiners in their decision making/planning process for complying with the low sulfur diesel program requirements? Are the necessary resources and plans

being put in place to ensure that refiners are on track for meeting the 15 ppm sulfur diesel standard in 2006?

4. What is the current status of new or improved desulfurization technologies?

The CDIRP held meetings in the Washington, D.C. area in May, June, July, and September of 2002. The Panel's review process included hearing presentations on technology progress and/or issues from EPA and other industry experts and stakeholders (see Appendix I for list of presenters).

Panel members and other interested parties also examined and commented on EPA's *Highway Diesel Progress Review* report.[3] For this report, EPA interviewed virtually all the major engine and catalyst manufacturers, refiners, and refinery technology vendors. The Agency concluded that although it is still early in the process, every major engine manufacturer expects to have emission-compliant products by 2007. In addition, EPA concluded that the refining industry is where the Agency anticipated it to be, and some are actually ahead of schedule. Panel members and other stakeholders provided detailed comments on the report to EPA.

The primary focus of the panel's efforts were to provide its own answers to the Four Questions provided to the Panel by EPA. At its July Meeting, the Panel formed Working Groups to address these questions and the Panel's conclusions below resulted from the efforts of those Working Groups, and agreements reached among the Panel at its meeting of September 24-25, 2002.

III. Implementing the 2007 Rule

From its first meeting, Panel members agreed that the primary goal looking forward was *not* to contest aspects of the rule, but rather for all parties to work cooperatively together for the successful implementation of the rule. In this spirit, the discussion of technology progress

developed by the Panel was designed to measure progress, and set the stage for future monitoring and steps by all parties to ensure an effective and successful rule.

(Chairman's Note: The following reflects the current state of opinion among those Panel members who responded to my earlier proposed language to address these other implementation issues. Although I did not hear from all members, and have not done a formal poll of members on these three options, I would characterize them as follows:

1. *This is language which the largest number of individual members might support*
2. *This is language proposed by some members to more fully identify these issues in the text*
3. *This is language proposed by some members suggesting that these issues should be briefly but not specifically acknowledged in the text)*

(1) As would be expected with the implementation of any important, complex, and far-reaching rule like the 2007 Highway Heavy Duty Diesel Rule, the Clean Diesel Independent Review Panel heard at its meetings of a number of potential issues that may need attention to ensure that the rule is implemented smoothly and efficiently. While some of these issues fell within the direct charter and questions directed by EPA to the Panel, and are addressed in the Panel's Conclusions (see Section IV. Below), a number of these issues were outside the charter, and therefore the Panel was not constructed to be able to fully address them. Among such issues identified in the discussions were: sulfur testing methods (including reference and in-line methods), pipeline and distribution system operations to ensure that compliant fuel reaches the vehicles, and efforts to ensure proper fueling during the period when two types of highway diesel will be available. Detailed descriptions of these and other issues have been forwarded on to EPA, and can be found in Appendix I available at http://www.epa.gov/air/caaac/clean_diesel.html.

As these other implementation issues arose, Panel members agreed that important issues often arise during the implementation of any complex rule like the 2007 Heavy-Duty Diesel Rule, so the existence of such issues should not be unexpected, nor should it be construed as a criticism of EPA's rule-making process or its ongoing implementation activities. The Panel was

advised during its deliberations that EPA is meeting already with key stakeholders to identify and address any such implementation issues that might need future attention. The Agency also has indicated that it plans to hold workshops later this year to identify what, if any, future actions may be necessary to ensure smooth implementation. The Panel agreed that EPA was taking valuable steps with all key implementation parties to help achieve successful and timely implementation of the rule.

(2) As would be expected with the implementation of any complex and far-reaching rule like the 2007 On-Road Heavy Duty Diesel Rule, the Clean Diesel Independent Review Panel heard at its meetings of a number of potential issues that may need attention to ensure that the rule is implemented smoothly and efficiently. . While the four EPA questions are narrowly framed, the CDIRP charter defines the questions that the panel is to address in a much broader manner. For example, objective 2 of the CDIRP charter charges the panel to assess the progress of "the fuels industry in developing and demonstrating technologies to effectively lower the sulfur level of highway diesel fuel". The fuels industry encompasses not just refinery desulfurization units but includes refinery distribution systems, pipelines, terminals and marketing/distribution facilities. In each of these other areas there are additional issues that must be addressed for proper implementation of the Highway Diesel Regulation.
The Panel acknowledges that these issues, identified in both comments and presentations from the Panel members and from the public, may be important to the successful implementation of the rule. These issues include:

- *sulfur measurement/detection technology at the refinery, pipeline, terminal and retail levels;*
- *the ability of the fuels industry to adapt to carry two grades of highway diesel fuel, LSD-Low Sulfur Diesel (<500 ppm sulfur) and ULSD-Ultra-low Sulfur Diesel (<15 ppm sulfur);*
- *the ability of the fuels industry to deliver adequate supplies of ultra-low sulfur kerosine to meet the winterization requirements of ULSD*
- *the significant amount of contamination and losses anticipated to occur throughout the refinery and distribution systems;*

- *the presence of adequate facilities to store, transport and reprocess transmix and contaminated interfaces;*
- *the technology to prevent misfueling that is still to be developed, plus the resolution of misfueling liability issues;*
- *the understanding among marketing facilities of the regional variations in the ratios of ULSD, LSD, and HSD supplies; and*
- *the overall ability of the fuels industry to deliver adequate supplies of ULSD and LSD to the appropriate highway and non-road diesel vehicles.*

Detailed descriptions of these and other issues have been forwarded on to EPA, and can be found in Appendix I available at http://www.epa.gov/air/caaac/clean_diesel.html.

The panel was pleased to learn during its deliberations that EPA had begun to meet with key stakeholders to identify those implementation issues that were of priority concern, and that the Agency planned to also hold workshops later this year to identify what, if any, actions were necessary to ensure smooth implementation. The Panel agreed that the goal looking forward was to achieve successful implementation of the rule, and encouraged EPA to expeditiously gain input from affected stakeholders, conduct its review, and, as necessary, act to address these other issues.

(3) As would be expected with the implementation of any complex and far-reaching rule like the 2007 On-Road Heavy Duty Diesel Rule, the Clean Diesel Independent Review Panel heard at its meetings of a number of potential issues that may need attention to ensure that the rule is implemented smoothly and efficiently. While some of these issues fell within the direct charter of the Panel to consider the technology progress toward implementing the rule, a number of these issues were outside the charter. For those that are interested, descriptions of these and other issues can be found at http://www.epa.gov/air/caaac/clean_diesel.html.

IV. The Panel's Conclusions: Answering the Four Questions

Overall, the Panel found that there has been much progress toward the technology development necessary to implement the 2007 Heavy-Duty On-Road Diesel Rule. At the same time the Panel acknowledged that, as would be the case with any such rule where new technologies have to be developed and implemented, important progress remains to be accomplished. The Panel's specific response to the Four Questions are below:

1. What is the current status of the NO_X adsorber technology to meet the provisions of the HD2007 regulations given diesel fuel with a sulfur cap of 15 ppm? Is industry making progress to develop NO_X adsorbers in a timely manner? Are the necessary resources and plans being put in place to ensure that the technology is available in 2007? What other technologies are being pursued/developed to enable or facilitate the application of NO_X adsorbers?

2. What is the current status of catalyzed diesel particulate filters to meet the provisions of the HD2007 regulations given diesel fuel with a sulfur cap of 15 ppm? Is industry making progress to develop the catalyzed diesel particulate filter in a timely manner? Are the necessary resources and plans being put in place to ensure that the technology is available in 2007?

(Chairman's note: the following is the language agreed by the Working Group on Questions 1 and 2) Over the course of three months of discussion and presentations, the Clean Diesel Independent Review Panel reached a consensus that significant progress is being made to develop emission control technologies for use in diesel engines starting in model year 2007. The Panel has also identified specific engineering challenges that must be resolved for successful final implementation. While there are other possible technologies that might be employed in 2007, the two that appear most likely, and which were given most attention by the EPA in their progress report, are NOx adsorbers and catalyzed particulate filter systems. Consequently, these are the technologies given attention by the Panel.

NOx Adsorbers

The Panel's review of NOx adsorbers is a current "snapshot" of progress, taken eight years before full production compliance is required. The 2007 Rule does not require 100 percent compliance with the 0.2 g/bhp-hr NOx standard until 2010. Reducing emissions from the 2004 standard of 2.4/2.5 g/bhp-hr (NOx and NMHC combined) to 0.2 g/bhp-hr will require NOx adsorbers that can operate reliably and durably at up to 95 percent efficiency. While there are important technical challenges that must be resolved before NOx adsorbers can achieve this level, bench and dynamometer testing has already demonstrated adsorber efficiencies at 70 percent and more, leading Panel members to conclude that the technology is making significant progress toward successful implementation in the 2007-2010 timeframe. Given that full, industry-wide compliance with this standard is not required until 2010, this is a critically important finding.

The Panel noted that this rapid technology development is due to the certainty provided by the finalization of the 2007 Rule, which confirmed future sulfur levels and timetables for the new emission standards. Because of the 2007 Rule, engine manufacturers, vehicle manufacturers and aftertreatment manufacturers are making tremendous investments now to ensure the successful development and implementation of the NOx adsorber technology in time for the 2007 Rule's implementation.

Despite the significant progress, the Panel also discussed a number of technical challenges that must be resolved for the successful introduction of NOx adsorbers in the 2007-2010 time frame. The Panel recognizes the lesser maturity level of the development of this device compared to particulate filters. The issues discussed by the Panel included:

Temperature range: NOx adsorber efficiency must be expanded over a wider range of operating temperatures.

Durability: Improve catalyst efficiencies over the full useful life of the system (e.g., thermal durability).

Desulfation: NOx adsorber efficiency is reduced by sulfur, so the adsorber must be "desulfated" periodically. Both desulfation method and performance require improvement.

System integration: including packaging constraints and fuel economy impacts.

Several panelists also mentioned migration of precious metal elements and substrate issues for future resolution.

Some of these have been described as "fundamental technical issues." In each case, Panel members found significant commitment of resources to address these issues, and that progress is being made. Panel members agreed that, while we do not know the solutions now, none is considered to be insurmountable at this time

Improving the durability of the NOx adsorber, especially as it relates to desulfation, is the most significant fundamental challenge that is being addressed currently. This will require further materials improvements, in addition to better temperature and air-fuel ratio control during the desulfation process. Recent progress is impressive, with some gasoline systems showing minimal deterioration, but these need to be adapted for diesel use. Many alternatives have been proposed for desulfating procedures and are in development. Adsorber technologists are assessing various options to determine which process best meets the needs of diesel applications.

Because of the state of maturity of the technology, the improvements are being driven by bench testing and dynamometer testing. Vehicle integration strategies and development are in the infant stages. NOx adsorbers are not being tested and integrated into full heavy-duty diesel vehicles yet. However, it is important to note that they are being integrated into light-duty diesel vehicles and are demonstrating low NOx emissions on the Federal Test Procedure. For example, Toyota has tested a light-duty vehicle at emission levels near the Tier 2 Bin 5 level, commonly thought to be beyond the current level of light-duty diesel emissions control technology (this vehicle is not yet certified by EPA). While there are many differences between light-duty and

heavy-duty diesel engines, vehicles, duty cycles and durability requirements, EPA and some Panel members thought the Toyota developments would be instructive to heavy-duty NOx adsorber developers.

Catalyzed Diesel Particulate Filters (CDPFs)

The Panel reached consensus that PM filters will be necessary and available to meet the 2007 PM standard. Today's PM filters are the latest stage in more than twenty years of PM filter development in North America, Europe and Japan.

The Panel found that Catalyzed Diesel Particulate Filters (CDPFs) are more mature than NOx adsorbers. At this point, transit buses, school buses and other diesel vehicles are being retrofit with CDPFs and other particulate filters throughout the nation, and CDPFs are being used throughout Europe and elsewhere. Using passive PM filters in commercial applications enhances the development process towards a wider use of CDPFs by providing a wide range of real world usage.

International Truck and Engine Company has already certified a CDPF-equipped engine at the 2007 PM standard as well as the 2007 hydrocarbon standard. These engines are limited to vehicle applications that fit the proper exhaust temperature profile and only use 15 PPM maximum sulfur diesel fuel.

CDPF developers are focusing on three primary areas of development as they prepare for 2007:

Active regeneration: Active regeneration will be mandatory for all diesel vehicles with particulate filters in 2007 to ensure that the filter regenerates when the load factor is not sufficient for passive regeneration. The majority of medium and light heavy diesel applications, as well as lightly loaded heavy heavy duty diesels, will require active regeneration.

Ash handling: Further design enhancements of the filters will be required to minimize ash loading consequences. Development and use of very low ash oils will also be required. Reliable service practices and infrastructure must be in place for filter cleaning, and acceptable service intervals must be established.

Pressure drop reduction: The design of the filter as well as the active regeneration strategies require further development to minimize the filter pressure drop and, thereby, improve vehicle fuel efficiency.

In addition to these three specific issues, full vehicle integration is an important development requirement, including integrating particulate filter systems with NOx adsorber systems.

Summary of Responses to Questions 1 and 2

The Panel found that significant progress is being made to develop NOx adsorbers and catalyzed particulate filter systems for use in diesel engines in 2007. NOx adsorbers and catalyzed particulate filter systems are the primary technologies being developed by engine manufacturers, vehicle manufacturers and aftertreatment manufacturers in North America, Europe and Japan for US applications in 2007. The worldwide focus on a particular technology significantly enhances its potential for success. In each case, the Panel found examples of significant progress that has occurred since the 2007 Rule was finalized in 2001.

Companies are rapidly moving beyond purely technical issues to address product development issues like fuel economy impacts and “first cost.” “First cost” numbers are being discussed as a factor in selecting technology alternatives. Other product development issues, such as reliability, long-term durability, maintenance and fuel economy are also being addressed. Cost issues and other product development issues were beyond the Panel’s discussion, since we did not have access to company confidential cost and other data. Many of these are “system level” issues, i.e., issues related to integrating aftertreatment equipment with vehicle and engine platforms. Ensuring successful integration of aftertreatment, engine and vehicle systems to

produce the best product for the customer is a critical piece of the engineering and product development work that lies ahead.

In sum, the Panel is very encouraged by the rate of progress to date. Technical challenges remain to be resolved. However, Panel members agreed that, while we do not know the solutions now, none is considered to be insurmountable at this time. The next twelve months of development will be extremely important. It is important that the velocity of NOx adsorber development be confirmed, that system integration strategies progress to the hardware stage, and that technology confirmation decisions be made by companies in order to prepare for 2007 product introduction.

3. Which refiners have announced their plans for producing low sulfur diesel fuel by June 2006? Where are refiners in their decision making/planning process for complying with the low sulfur diesel program requirements? Are the necessary resources and plans being put in place to ensure that refiners are on track for meeting the 15 ppm sulfur diesel standard in 2006?

There is a general agreement that there are no technological impediments to refineries proceeding with desulphurization and that in general refiners are where they are expected to be. In some cases, refiners have made the decision to desulfurize and have proceeded with implementation ahead of schedule. Other refiners are still assessing their options as is appropriate at this point in time. *(Chairman's Note: From this point onward, the Working Group on Question 3 differed on how to characterize the current status. I have included below the differing proposals, (A) and (B), and a third proposal (C) that I drafted based on the other two:*

(A) This assessment includes among other items a review of technology alternatives and costs, the degree of desulphurization needed in order to comply with the Rule, and other factors not directly related to the Rule. EPA has indicated that it will continue to monitor these issues in the period between now and 2006 to identify and address any issues that may emerge. EPA has committed to have implementation workshops over the next several months to aid the industry in understanding the rule's

requirements and guide them as they work to resolve the issues they will face in implementing the rule. Also by June, 2003 and again in June 2004 and 2005 all refiners will be reporting to EPA their plans for compliance and this information will be shared back with the industry in a non-confidential format to help them make their decisions for implementing the rule.

(B) *Some refiners have announced plans to shutdown or sell refineries. Other refiners are still waiting for EPA to finalize the Non-road diesel regulations and/or are assessing their options as is appropriate at this point in time. This assessment includes among other items a review of technology alternatives and costs, the degree of desulfurization needed in order to comply with the Rule, and the viability of remaining in the refining business. EPA has indicated that it will continue to monitor these issues in the period between now and 2007 to identify and address any barriers that may emerge.*

(C) *<u>Chairman's Suggestion for Discussion:</u> There is a general agreement that there are no technological impediments to refineries proceeding with desulphurization and that in general refiners are where they are expected to be in assessing technology alternatives and costs, the degree of desulfurization needed in order to comply with the Rule, and market and other factors not directly related to the Rule but always important to refinery decision-making. In some cases, refiners have made and announced decisions. Other refiners are still assessing their options.*

The Panel found that it was encouraging to see the industry moving forward with decisions, but that, as expected at this point, a number of key decisions remain to be made and monitored. EPA has indicated that it will continue to monitor these decisions in the period between now and 2006 to identify and address any issues that may emerge (by June, 2003 and again in June 2004 and 2005 all refiners will be reporting to EPA their plans for compliance). The Panel found it critically important that this information will be shared back by EPA with the industry in a

timely fashion and in a non-confidential format to help them make their decisions for implementing the rule in the most effective manner.

4. What is the current status of new or improved desulfurization technologies?

(Chairman's Note: the following is the language agreed by the Working Group on Question 4) As anticipated there have been introductions of new technologies for the desulfurization of diesel as well as improvements to the existing technology portfolio. Information presented during the review process confirmed that new technologies are being developed that will potentially be utilized to assist refiners in producing ULSD from existing assets or that will potentially be able to produce ULSD as a new stand alone application. Commercial demonstration plants are currently under construction in at least two new technologies; however, it is not clear at this time if the commercial demonstration plants will be operating and producing stable and consistent results in time for most refiners to make their compliance decisions for 2006.

Overall Summary and Conclusions*(Chairman's Note: the following is my first cut - obviously subject to discussion and revision at the meeting)*

In summary, the Panel found substantial progress on the development of engine and emission technologies necessary to meet the rule, and as would be expected in such a program, important progress still to be made, especially in the development of NOx adsorbers and in system integration. On the fuel side, the Panel found the refining industry to be at the stage in their decision process for rule compliance that would be expected at this stage in rule implementation, with each company assessing, among other items, technology alternatives and costs, the degree of desulphurization needed in order to comply with the Rule, and other industry and market factors not directly related to the Rule. The Panel also found evidence of promising new and refined desulfurization technologies in development, although it is not clear at this time if the commercial demonstration plants will be operating and producing stable and consistent results in time for most refiners to make their compliance decisions for 2006.

On both the engine and fuel sides, the Panel found that key decision points will be occurring

over the coming months and years. EPA indicated to the Panel their intention to engage - in meetings and workshops - with all implementing parties to track the progress toward implementation. The Panel encouraged EPA to pursue these activities fully, indicating that full and fair dialogues with EPA were essential to timely and efficient implementation of the rule.

V. Acknowledgments

The Panel would like to acknowledge several individuals for their invaluable assistance in preparing this report. First and foremost the Panel thanks Mary Manners, our Designated federal Official, for her hard work, excellent communication, and "special" contributions to Panel energy levels, and to the staff of EPA for their information and presentations. We would also like to thank the many individuals who presented to the panel and/or provided comments. Finally, we appreciate greatly the assistance of our contract support team Rebecca Battye and Kathy Boyer.

1. Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements; Final Rule. EPA; 40 CFR Parts 69, 80, and 86. Federal Register/Vol. 66, No. 12, Thursday, January 18, 2001.

2. Health Assessment Document for Diesel Exhaust, September 2002

3. U.S. EPA. *National-Scale Air Toxics Assessment for 1996.* EPA-453/R-01-003, January 2001. Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

4. U.S. EPA, Office of Air and Radiation. *Highway Diesel Progress Review*. EPA420-R-02-016, June 2002. (http://www.epa.gov/air/caaac/dieselreview.pdf)

5. Charter of the Clean Diesel Independent Review Panel.....add citation details